PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:

Otto-Aleksanteri LEHTINEN et al.

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For: PARAMETER SELECTION OPTIMIZATION FOR HANDOVER

CLAIM FOR PRIORITY UNDER 35 USC § 119

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

January 14, 2004

Sir:

The benefit of the filing dates of the following prior foreign application filed in the following foreign country is hereby requested for the above-identified patent application and the priority provided in 35 U.S.C. §119 is hereby claimed:

European Patent Application No. 03014322.6 filed on June 25, 2003 in Europe

In support of this claim, certified copy of said original foreign application is filed herewith.

It is requested that the file of this application be marked to indicate that the requirements of 35 U.S.C. §119 have been fulfilled and that the Patent and Trademark Office kindly acknowledge receipt of this document.

Please charge any fee deficiency or credit any overpayment with respect to this paper to Counsel's Deposit Account No. 50-2222.

Respectfully submitted,

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Enclosure: Priority Document

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Bescheinigung

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Attestation

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. Patent application No. Demande de brevet n°

03014322.6

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

R C van Dijk

Anmeldung Nr:
Application no.: 03014322.6
Demande no:

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Parameter selection optimazation for handover

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Parameter Selection Optimization for Handover

FIELD OF THE INVENTION

The present invention relates to a method and device for selecting a handover parameter in a cellular network, such as a Universal Mobile Telecommunications System Radio Access Network (UTRAN).

BACKGROUND OF THE INVENTION

In cellular networks, handover is a functionality that switches the user equipment (UE) from one cell to another due to various reasons, wherein the main reason for handover is usually the fact that the other cell can provide a service with less power, i.e. less link budget. There are several parameters that control the handover decision making in a noisy multi-path channel. These parameters can be optimised depending on various conditions to maximise the network capacity or to enable auto configuration in the UTRAN. In the time division duplex (TDD) mode of the UTRAN, a Wideband Code Division Multiple Access (WCDMA) handover procedure is performed as described for example in the Third Generation Partnership Project (3GPP) specification TR 25.922, v.0.5.0, "Radio Resource Management Strategies".

In particular, the handover procedure consists of a set of parameters to be set. These parameters comprise among others a hysteresis value in the active set update, and the length of an averaging window for power measurements. These parameters play an important role in adjusting the sensibility of handover in the presence of fast channel variations and measurement errors. The added hysteresis prevents unnecessary and frequent handovers (ping-ponging) that mainly disturbs quality of the connection, reduces the overall system capacity and introduces unnecessary signalling load. Furthermore, measured received signal code power

(RSCP) values are averaged over some time to prevent handover due to short-term variations in the signal.

In a real network, also some delay is involved in the handover execution. When a terminal device, or user equipment (UE) in the UTRAN terminology, triggers a handover report, which means that the RSCP value of a candidate cell exceeds the RSCP value of the active cell by the hysteresis value, it takes some time before the handover report is delivered to the network device responsible for the handover operation, e.g. a radio network controller (RNC). Furthermore, some delay is involved in the processing of a handover message, setting-up of a connection between the RNC and a serving base station, or Node B in the UTRAN terminology, and allocation of radio resources for the UE in the new Node B. Further details concerning these measurements and related accuracy requirements can be gathered e.g. from the 3GPP specifications TS25.123, "Requirements for Support of Radio Resource Management (TDD)", and TS25.225, "Physical Layer Measurements".

Usually, the handover decision making is based on a comparison between an observed value and a predetermined threshold value, wherein the threshold value is chosen in a manner to maximise the system capacity under various conditions. However, the above handover delay causes interference and switching back and forth causes additional interference due to a prolonged connection to the old cell. Moreover, if the channel conditions are not favourable to sustain the connection in the new cell, correction of the improper handover decision is delayed and additional interference is generated.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an optimised parameter setting and capacity.

This object is achieved by a method of selecting a handover parameter in a cellular network, said method comprising the steps of:

- measuring a delay of a handover procedure; and

- setting the handover parameter based on the result of the measuring step.

Furthermore, the above object is achieved by a network device for selecting a handover parameter in a cellular network, the device comprising:

- measuring means for measuring a delay of a handover procedure;
- setting means for setting the handover parameter in response to the measuring means.

Accordingly, by setting or selecting the handover parameter based on a measured handover delay, system capacity can be maximized dynamically depending on the system load and physical configuration, which both determine the actual handover delay. Thereby, parameter and capacity optimisation becomes possible. Thus, system capacity can be maximised under varying conditions.

The handover parameter may be at least one of the hysteresis value for a handover threshold or the length of the averaging window use for measuring transmission quality of the radio connection. The handover parameter may be tuned dynamically based on the result of the measuring step. Of course, other suitable handover parameters can be selected based on the measured handover delay.

The handover delay may comprise at least one of a round trip delay of a physical layer protocol signalling, a delay between a radio network controlling device and a base station device, a measurement delay at a terminal device, and a processing delay of the cellular network. Specifically, the physical layer protocol may be a radio resource control protocol.

The result of the measuring step may be compared with a predetermined threshold, e.g. a threshold of 200ms in case of the hysteresis value.

The setting step may comprise setting the handover parameter to a first value when the measured handover delay is smaller than the predetermined threshold, and setting the handover parameter to a second value when the measured handover delay is not smaller than the predetermined threshold.

The measuring step may comprise measuring an acknowledged mode signalling round trip delay and estimating a pear to pear signalling delay based on the measured round trip delay. In particular, the measuring step may be based on a counting operation for counting time stamps.

As an alternative, the measuring step may comprise calculating or deducing said delay from a standard protocol message by using a common time reference.

As a further alternative, the measuring step may comprise measuring an uplink delay based on an event report propagation time using time stamps, and measuring a downlink delay based on a physical channel reconfiguration message.

The measuring means may comprise a frame counter for keeping a time stamp.

Further advantageous modifications are defined in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described on the basis of preferred embodiments with reference to the accompanying drawings in which:

Fig. 1 shows a schematic block diagram of a network architecture in which the present invention can be implemented;

Fig. 2 shows a schematic diagram indicating a measured time behaviour of the quality of a received signal and an example of a handover procedure;

Fig. 3 shows a diagram indicating a system capacity as a function of handover delay at various hysteresis values;

Fig. 4 shows a schematic block diagram of a handover parameter selection functionality according to the preferred embodiments;

Fig. 5 shows a schematic signalling diagram of a protocol signalling of a handover operation; and

Fig. 6 shows a schematic flow diagram of a hysteresis selection procedure according to the preferred embodiments.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments will now be described on the basis of a third generation WCDMA radio access network architecture, e.g. a UTRAN as shown in Fig. 1.

Fig. 1 shows a terminal device or UE 10 connected via an air interface to a first Node B 20 and a second Node B 22. It is noted that the Node B is a base station device in third generation radio access networks. In the present case, it is assumed that the UE 10 is intended to be handed over from the second Node B 22 to the first Node B 20. The first and second Node Bs 20, 22 are connected via respective Iub interfaces to first and second radio network controllers (RNCs) 30, 32 which are connected to each other via an Iur interface. The Node Bs 20, 22 are logical nodes responsible for radio transmission and reception in one or more cells to/from the UE 10 and terminate the Iub interface towards the respective RNCs 30, 32. The RNCs 30, 32 are in charge of controlling use and integrity of radio resources within the radio access network. In particular, the RNCs 30, 32 are in charge of controlling handover operations from one Node B to another Node B. Furthermore, the RNCs 30, 32 provide connections to a third generation core network 40, e.g. a UMTS network for both circuit-switched traffic via a Iu-CS interface and packet-switched traffic via a Iu-PS interface. The existence of an open standardized Iur interface is essential for proper network operation, including handover support in a multi-vendor environment. It should be noted that in a typical case many node Bs are connected to the same RNC.

In the present case, the UE 10 is served by the second RNC 32 via the second Node B 22. Hence, the second RNC 32 has a serving RNC (SRNC) functionality, which is a role an RNC can take with respect to a specific connection between a UE and the UTRAN. There is one SRNC for each UE that has a connection to the UTRAN. The SRNC is in charge of the Radio Resource Control (RRC) connection between the UE 10 and the UTRAN.

Furthermore, it is assumed that the first RNC 30 has a Controlling RNC (CRNC) functionality, which is a role an RNC can take with respect to a specific set of UTRAN access points. There is only one CRNC for any UTRAN access point. The CRNC has overall control of the logical resources of its UTRAN access point. An UTRAN access point is a conceptual point within the UTRAN performing radio transmission and reception. An UTRAN access point is associated with one spe-

cific cell, i.e. there exists one UTRAN access point for each cell. Thus, the access point is the UTRAN-side end point of a radio link. In Fig. 1, the first and second Node Bs 20, 22 are UTRAN access points.

Fig. 2 shows a schematic diagram of a time behaviour of a measured signal quality at the UE 10. In particular, a measured ratio E_C/I_0 is indicated on the vertical axis, which corresponds to the ratio of energy per modulating bit to the total received power spectral density, including signal and interference, as measured at the antenna connector of the UE 10.

In Fig. 2, the example handover control keeps track of candidate cells whose quality would be sufficient for transmission and reception but which are not yet selected as active cells. Any cell whose received signal code power of the Primary Common Control Physical Channel (P-CCPCH) exceeds a first predetermined level T_add is added to a candidate set, as shown at point 1 of Fig. 2. If the maximum size of the candidate set is exceeded, a new cell may be added to the candidate set only if the RSCP level of the new cell exceeds the RSCP level of one cell in the candidate set by a certain hysteresis threshold value T, as indicated at point 2 in Fig. 2. Then, the weakest cell is removed from the candidate set and the new cell is added. If the UE 10 notices from its power measurements that the RSCP of a candidate set cell exceeds that of the active cell by the hysteresis threshold T, a new cell is selected to be an active cell, while the current active cell is dropped to the candidate set, as indicated in points 3 and 4 of Fig. 2. In this respect, a reference level $RSCP_{ref}$ indicates the RSCP level of a reference active cell in Fig. 2. As the measured RSCP level of a cell B exceeds the reference level $RSCP_{ref}$ between points 3 and 4 in Fig. 2, the corresponding Node B which serves cell B is set to the active state.

As can be gathered from Fig. 2, the added hysteresis value T prevents unnecessary and frequent handovers which mainly disturb quality of the connection, reduce overall system capacity and introduce unnecessary signalling load. Furthermore, it is noted that the measured RSCP values may be averaged over some time to prevent handover due to short-term variations in the signal.

If the measured RSCP of a cell drops below a second predetermined level T_drop, as indicated at point 5 in Fig. 2, then the UE 10 starts a timer. The corresponding base station is then dropped from the candidate set if the RSCP level stays below the second threshold T_drop for a predetermined time, i.e. the guard time GT, as indicated at point 6 of Fig. 2.

Consequently, the number of handovers will decrease as the hysteresis value T is increased. This is predictable, since higher hysteresis requires higher RSCP for a new Node B or base station to be selected and no handovers are made due to fast and temporary changes in the RSCP level. Thus, the rate of active set updates gets slower.

Furthermore, the length of the averaging window also has a clear impact on the number of handovers and consequently on the rate of active set updates. Namely, the enlargement of the averaging window prevents unnecessary handovers due to fast channel variations. When the filtering length of the averaging window is high, some delay is introduced to the handover execution when the UE 10 penetrates to the area of an adjacent cell while communicating with high powers with the other Node B. This leads to high interference to the new Node B and thus capacity loss for the system.

According to the preferred embodiments of the present invention, the handover parameters, such as the hysteresis value T, the length of the averaging window or other suitable parameters, are selected based on a measured handover delay to thereby optimise parameter selection.

Fig. 3 shows a diagram indicating system capacity as a function of handover delay at various hysteresis values. As can be gathered from Fig. 3, a hysteresis value T=1dB provides a high system capacity at low delay values, while a Hysteresis value T=6dB provides a high system capacity at higher delay values. The system capacity is indicated here as the number of UEs per base station per time slot.

Hence, it can be gathered from Fig. 3, that the hysteresis value T can be selected in dependence on the measured handover delay to thereby improve overall system capacity. In particular, the handover delay, which consists of RRC Round Trip Delay, RNC-to-Node B delay, UE measurement delay and UTRAN processing delay is measured. Then, the measured value can be compared to a predetermined threshold value, and an appropriate hysteresis value can be selected based on the comparison result. Furthermore, the hysteresis value T can be tuned dynamically in accordance with the measurement result.

Based on the measured conditions shown in Fig. 3 and parameters believed to represent a typical case, the threshold value or the handover delay can be set e.g. to 200ms. Then, if the delay is lower than 200ms, a hysteresis value T=1dB is selected for handover, while otherwise a hysteresis value T=6dB is used. Of course,

other suitable delay threshold values and hysteresis values may be selected based on specific requirements of the application.

Fig. 4 shows a schematic block diagram of a handover control functionality as implemented e.g. at the SRNC 32 in Fig. 1. The handover control functionality comprises a handover control unit 326 which is adapted to generate a corresponding handover control signalling to be supplied to the respective UEs via respective Node B devices. Based on these handover control signallings, a delay measuring unit 322 detects or measures or calculates the handover delay and supplies the result to a hysteresis selection unit 324 which selects a suitable hysteresis value T and supplies it to the handover control unit 326. It is noted that the units 322, 324 and 326 may be implemented as concrete hardware units or as subroutines controlling a processing unit at the SRNC 32.

The handover delay, e.g. signalling and decision making delay for the handover operation, as indicated in Fig. 3 can be measured at the measuring unit 322 based on different approaches as defined in the following three preferred embodiments.

According to a first preferred embodiment, the handover delay can be measured using an RRC acknowledged mode (AM) signalling from the SRNC 32 to the UE 10. In this case, the delay measuring unit 322 of the SRNC 32 is adapted to measure the AM round trip delay and to estimate the peer-to-peer signalling delay based on this. The accuracy of one frame, e.g. +/-10ms would not have significant impact compared to the time duration for the delay threshold of the RRC signalling, e.g. 200ms. The measurement can be based on a time stamp provided by a frame counter function which may be implemented in the delay measuring unit 322. In this respect, it is assumed that keeping the time stamp of the signal alongside the acknowledgement does not lead to a significant error due to the fact that the system needs to have other counters as well to assure proper system operation.

According to a second preferred embodiment, a common time reference can be used at the delay measurement unit 322. The common time reference may be provided e.g. in order to provide location services, or other standard RRC messages wherein the signalling or handover delay is then calculated or deduced from these messages.

According to a third preferred embodiment, time stamps provided on the signalling received from the UE 10 can be used to measure e.g. the event 1G report propa-

gation time from the UE 10 to the SRNC 32, or another corresponding handover decision making entity, so as to obtain the uplink delay. Then, the downlink delay can be determined directly from the Physical Channel Reconfiguration message as defined e.g. in the 3GPP specification TS 25.331, Section 10.2.22, e.g. based on the activation time information element. The overall handover delay is then obtained at a delay measuring unit 322 as the sum of the uplink delay and the downlink delay.

Fig. 5 shows a schematic signalling diagram indicating a handover protocol signalling, based on which the handover delay can be obtained. In step 1, a measurement report, which contains the measured RSCP value or any other value indicating the received power is forwarded from the UE 10 to the SRNC 32. If the handover control unit 326 at the SRNC 32 decides to initiate a handover operation, a Radio Link Setup Request is issued and forwarded in steps 2 and 3 via the CRNC 30 to the Node B 22 serving the UE 10. In response thereto, the Node B 22 forwards a Radio Link Setup Response in step 4 to the CRNC 30 which forwards the Radio Link Setup Response to the SRNC 32 in step 5. Finally, in step 6, the Physical Channel Reconfiguration message is forwarded to the UE 10 to initiate a channel reconfiguration.

As already mentioned above, the measurement report forwarded in step 1 and the physical channel reconfiguration message forwarded in step 6 can be used in the third preferred embodiment to measure the uplink delay and the downlink delay, respectively.

Of course, other round trip measurement methods can be used for obtaining the handover delay at the delay measuring unit 322.

Fig. 6 shows a general schematic flow diagram of the hysteresis selection or setting operation according to the above first to third preferred embodiments. In step 101, the round trip delay is measured based on one of the above approaches according to the first to third preferred embodiment. Then, in step 102, the measurement result is compared with the predetermined delay threshold, e.g. 200ms. If the measured round trip delay is smaller than the predetermined threshold, a hysteresis value T=1dB is set in step 104 and the routine ends. On the other hand, if it is determined in step 102 that the measured round trip delay is not smaller than the predetermined threshold value, a hysteresis value T=6dB is set in step 103 and the procedure ends. Thereby, a suitable adaptation of the hysteresis value T to the system capacity can be obtained.

As an alternative, the flow diagram of Fig. 6 may return to the measuring step 101 after each of the hysteresis setting steps 103 and 104. Thereby, a continuous adjustment of the hysteresis value can be obtained.

According to a fourth preferred embodiment, the length of the averaging window used for determining the RSCP of the P-CCPCH can be selected based on the measured handover delay, e.g. round trip delay. As the length of the averaging window has an impact on the number of handovers and on the delay to handover execution, a similar relationship as indicated in Fig. 3 can be obtained for different lenghts of the averaging window. Hence, an optimisation of the system capacity and the handover parameters can be obtained by selecting a suitable length of the averaging window in response to a measured delay value.

Finally, it is to be noted that any other suitable handover parameter could be selected or set based on the measured handover delay. Furthermore, the parameter selection functionality indicated in Fig. 4 can be implemented in any other entity responsible for performing or controlling handover in the respective cellular network. Also, the delay measurement is not restricted to the above approaches of the first to third preferred embodiments. Any other available round trip measurement methods can be employed or even other measurement methods suitable for determining a decisive handover delay. The preferred embodiments may thus vary within the scope of the attached claims.

Claims

1. A method of selecting a handover parameter in a cellular network, said method comprising the steps of :
   a) measuring a delay of a handover procedure; and
   b) setting said handover parameter based on the result of said measurement step.

2. A method according to claim 1, wherein said handover parameter is a hysteresis value for a handover threshold.

3. A method according to claim 1, wherein said handover parameter is a length of an averaging window used for measuring transmission quality of a radio connection.

4. A method according to any one of the preceding claims, wherein said handover delay comprises at least one of a round trip delay of a physical layer protocol signalling, a delay between a radio network controlling device and a base station device, a measurement delay at a terminal device, and a processing delay of said cellular network.

5. A method according to claim 4, wherein said physical layer protocol is a radio resource control protocol.

6. A method according to any one of the preceding claims, wherein said handover parameter is tuned dynamically based on the result of said measuring step.

7. A method according to any one of the preceding claims, further comprising the step of comparing the result of said measuring step with a predetermined threshold.

8. A method according to claim 7, wherein said predetermined threshold corresponds to a hysteresis value of 200ms.

9. A method according to claim 7 or 8, wherein said setting step comprises the steps of setting said handover parameter to a first value when said measured handover delay is smaller than said predetermined threshold, and set-

ting said handover parameter to a second value when said measured handover delay is not smaller than said predetermined threshold.

10. A method according to any one of the preceding claims, wherein said measuring step comprises measuring an acknowledged mode round trip delay and estimating a peer-to-peer signalling delay based on the measured round trip delay.

11. A method according to claim 10, wherein said measuring step is based on a counting operation for counting time stamps.

12. A method according to any one of claims 1 to 9, wherein said measuring step comprises calculating or deducing said delay from a standard protocol message by using a common time reference.

13. A method according to any one of claims 1 to 9, wherein said measuring step comprises measuring an uplink delay based on an event report propagation time using time stamps, and measuring a downlink delay based on a physical channel reconfiguration message.

14. A network device for selecting a handover parameter in a cellular network, said device comprising:
   a) measuring means (322) for measuring a delay of a handover procedure; and
   b) setting means (324) for setting said handover parameter in response to said measuring means (322).

15. A device according to claim 14, wherein said handover delay comprises at least one of a round trip delay of a physical layer protocol signalling, a delay between a radio network controlling device (30, 32) and a base station device (20, 22) a measuring delay at a terminal device (10), and a processing delay of said cellular network.

16. A device according to claim 15, wherein said physical layer protocol is a radio resource control protocol.

17. A device according to any one of claims 14 to 16, wherein said handover parameter is a hysteresis value for a handover threshold.

18. A device according to any one of claims 14 to 17, wherein said handover parameter is a length of an averaging window used for measuring transmission quality of a radio connection.

19. A device according to any one of claims 14 to 18, wherein said measuring means (322) is arranged to derive said delay from an acknowledged mode signalling from a radio network controller (30, 32) to a terminal device (10) to be handed over.

20. A device according to any one of claims 14 to 18, wherein said measuring means (322) is arranged to calculate or deduce said delay from a standard protocol message.

21. A device according to claim 20, wherein said measuring means (322) is arranged to use a common time reference for calculating or deducing said handover delay.

22. A device according to any one of claims 14 to 18, wherein said measuring means (322) is arranged to measure an uplink delay based on an event report propagation time, and to measure a downlink delay based on a physical channel reconfiguration message.

23. A device according to claim 19 or 22, wherein said measuring means (322) comprises a frame counter for keeping a time stamp.

24. A device according to any one of claims 14 to 23, wherein said network device (30, 32) is a device responsible for handover in said cellular network.

25. A device according to claim 24, wherein said network device is a radio network controller (30, 32).

Abstract

The present invention relates to a method and device for selecting a handover parameter in cellular network, wherein a delay of a handover procedure is measured and the handover parameter is set based on the result of the measuring step. Thereby, the system capacity can be maximised dynamically depending on the system load and the physical configuration. An optimisation of parameter and capacity thus becomes possible.

[Fig. 6]

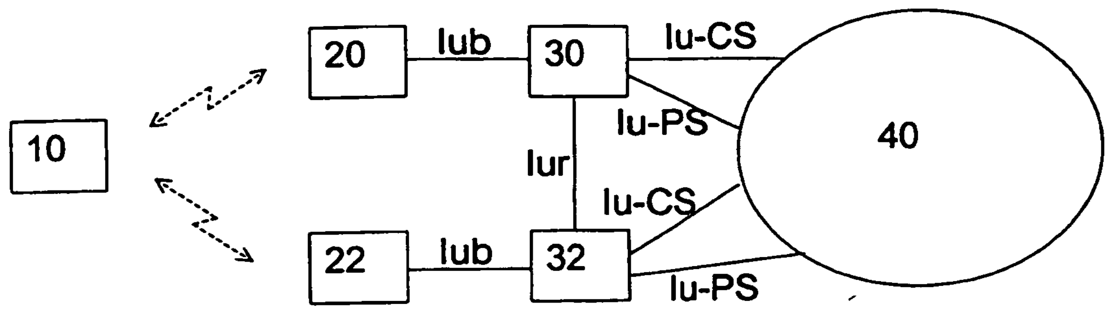
10
20
22
30
32
40
Iub
Iub
Iur
Iu-CS
Iu-PS
Iu-CS
Iu-PS

Fig. 1

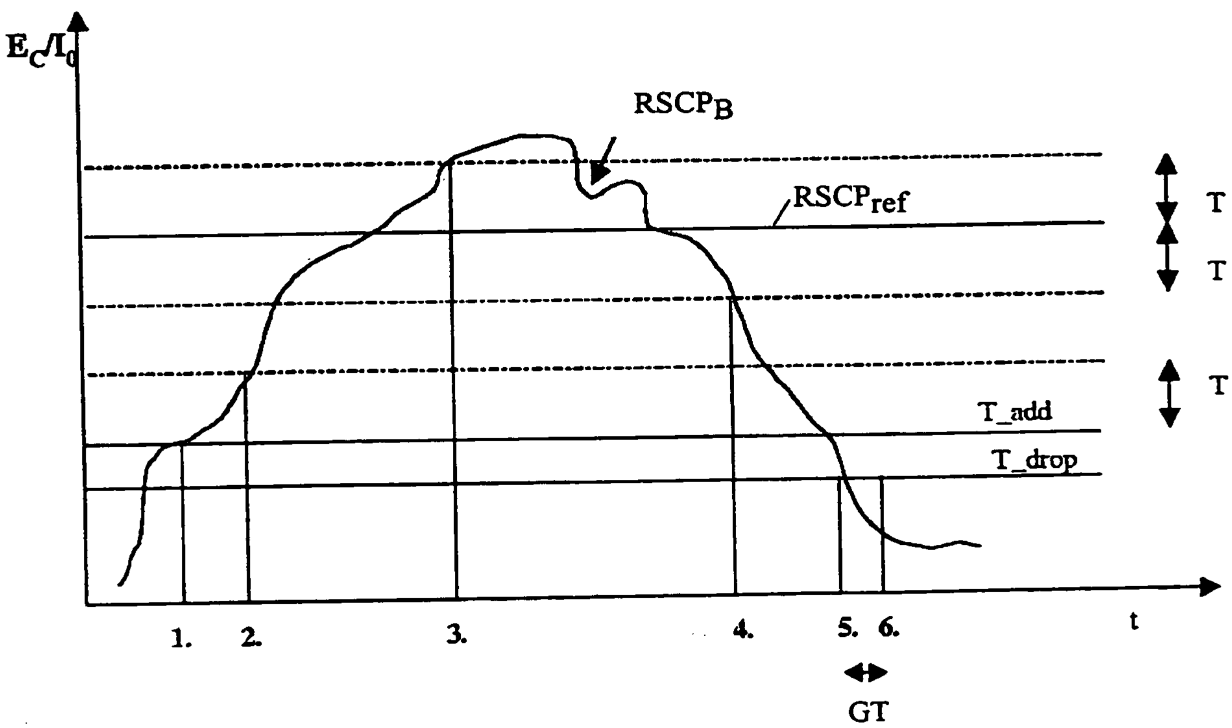
E_C/I_0
$RSCP_B$
$RSCP_{ref}$
T
T
T
T_add
T_drop
1.
2.
3.
4.
5.
6.
t
GT

Fig. 2

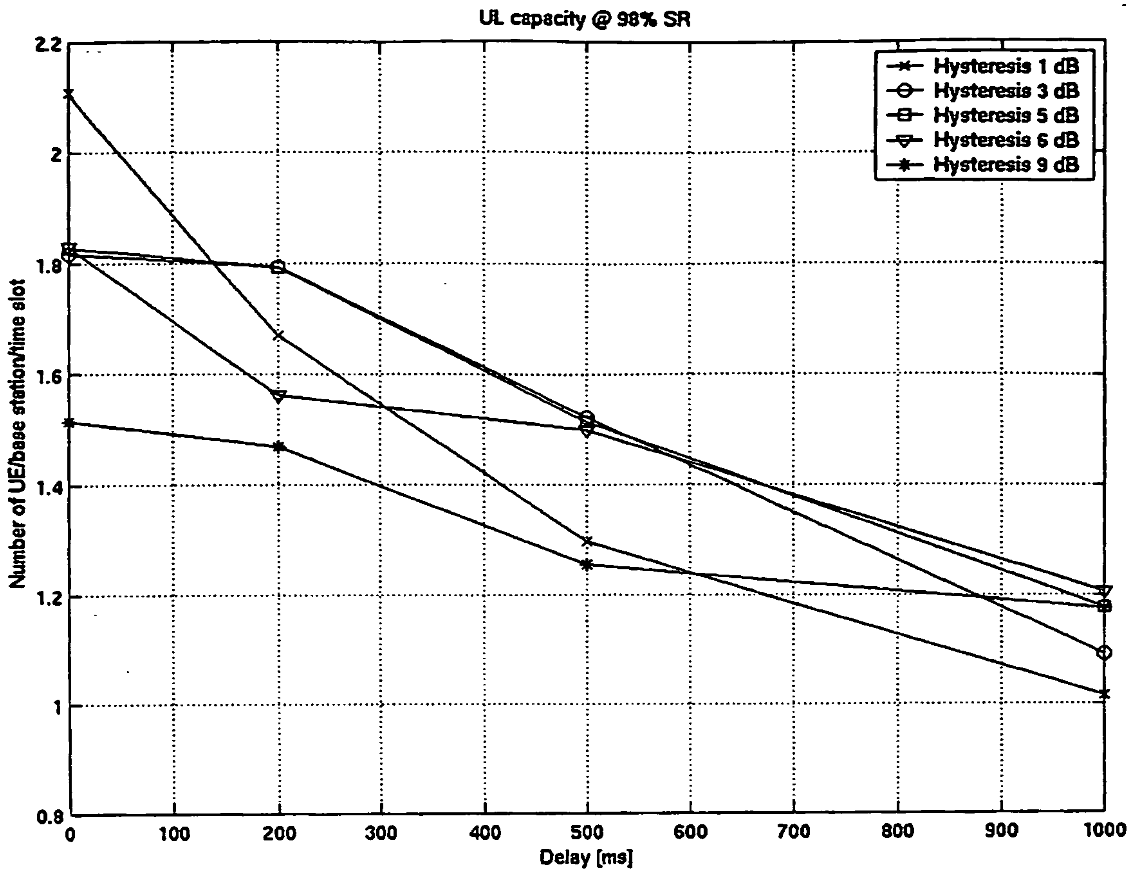
UL capacity @ 98% SR
Hysteresis 1 dB
Hysteresis 3 dB
Hysteresis 5 dB
Hysteresis 6 dB
Hysteresis 9 dB
Number of UE/base station/time slot
Delay [ms]
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0
100
200
300
400
500
600
700
800
900
1000

Fig. 3

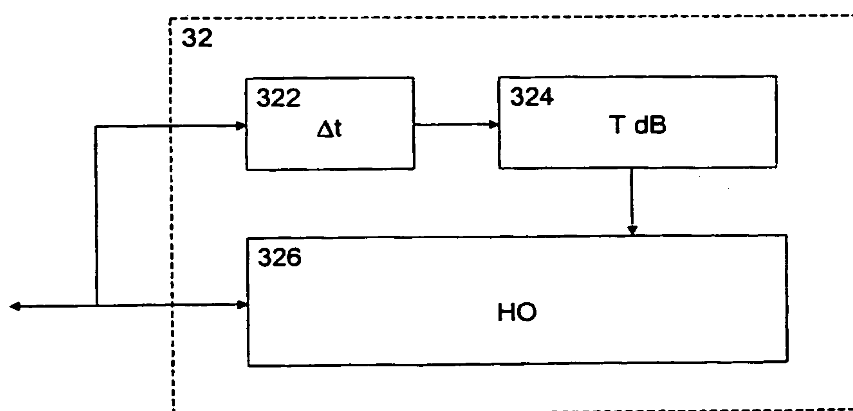
32
322
Δt
324
T dB
326
HO

Fig. 4

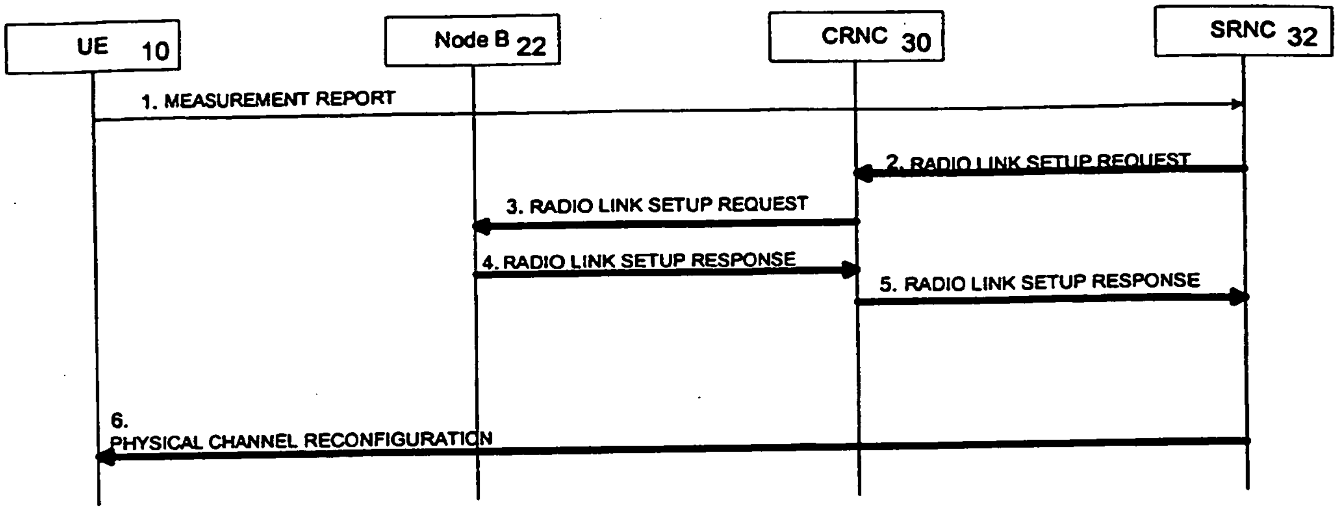
UE 10
Node B 22
CRNC 30
SRNC 32
1. MEASUREMENT REPORT
2. RADIO LINK SETUP REQUEST
3. RADIO LINK SETUP REQUEST
4. RADIO LINK SETUP RESPONSE
5. RADIO LINK SETUP RESPONSE
6.
PHYSICAL CHANNEL RECONFIGURATION

Fig. 5

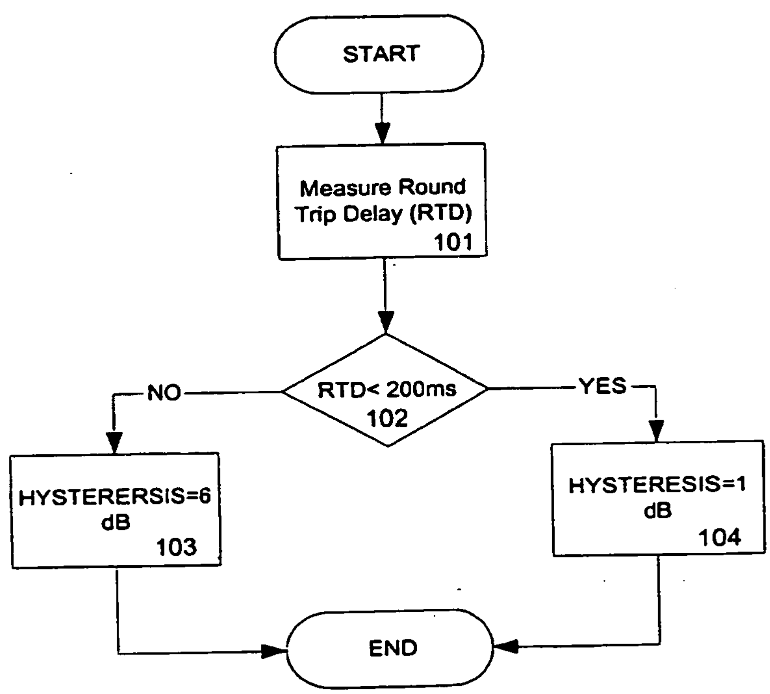
START
Measure Round
Trip Delay (RTD)
101
RTD< 200ms
102
NO
YES
HYSTERERSIS=6
dB
103
HYSTERESIS=1
dB
104
END

Fig. 6